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M.R.P. 1037A
31st March, 1957

AIR MINISTRY

METEOROLOGICAL RESEARCH COMMITTEE

Report of the Meteorological Research Committee to the Secretary of State for Air for the year ended 31st March, 1957

1. This is the fifteenth report submitted by the Committee which was constituted in September, 1941.

2. Membership. The members of the Committee at the end of the year were:-

Sir Charles Normand, C.I.E. (Chairman)
Sqn.Ldr. P. Barber (representing Air Staff)
Dr. G.E. Bell (representing Ministry of Transport and Civil Aviation)
Dr. A.W. Brewer
Dr. G.M.B. Dobson, C.B.E., F.R.S.
Instr. Captain A.E. Johnston (Director, Naval Weather Service)
Professor H.S.W. Massey, F.R.S.
Mr. J. Paton
Professor P.A. Shepperd
Sir Graham Sutton, C.B.E., F.R.S. (Director, Meteorological Office)
Sir Owen Wansbrough-Jones, K.B.E. C.B., (Chief Scientist, Ministry of Supply)
Dr. T.W. Wormell

Professor S. Chapman, F.R.S., the first Chairman and a member since 1941, ceased membership at the end of March, 1956. Towards the end of the year Instr. Captain P. Bracelin was succeeded by Instr. Captain A.E. Johnston, and Sqn.Ldr. A.W. Tarry by Sqn.Ldr. P. Barber.

3. Meetings. Two meetings of the Committee were held during the year.

4. Sub-Committees. Since early 1948 most of the detailed work of the Committee has been carried out by three Sub-Committees, each under the chairmanship of a member of the main Committee, which deal with investigations in three main fields, viz., instrument development and observation technique, synoptic and dynamical meteorology (including climatology) and physical meteorology. During the year the Instruments Sub-Committee held three meetings, the Synoptic Sub-Committee four and the Physical Sub-Committee five meetings.

The membership of the Sub-Committees at the end of the year was as follows (members of the Meteorological Office being marked by an asterisk):-

Instruments	Synoptic and Dynamical	Physical
Dr. A.W. Brewer (Chairman)	Prof. P.A. Sheppard (Chairman)	Dr. T.W. Wormell (Chairman)
Instr. Cdr. K.A. Bowell	Prof. H. Bondi	Dr. G.K. Batchelor
Mr. N.E.G. Hill	Instr.Cdr. K.A. Bowell	Instr.Cdr. K.A. Bowell
Dr. H.G. Hopkins	*Mr. C.J. Boyden	Prof. S. Chapman
Dr. A.J. Maddock	Dr. E.T. Eady	Prof. T.G. Cowling
Dr. B.J. Mason	*Dr. A.G. Forsdyke	Dr. R.M. Goody
Mr. S.W. Noble	Mr. E. Gold	Mr. A.S.G. Hill
*Mr. B.C.V. Oddie	Prof. M.J. Lighthill	Mr. F.H. Ludlam
*Dr. F.J. Scrase	*Mr. P.J. Meade	Dr. B.J. Mason
*Dr. J.M. Stagg	*Mr. S.P. Peters	*Mr. B.C.V. Oddie
*Dr. R.C. Sutcliffe	*Mr. J.S. Sawyer	*Dr. F. Pasquill
	Dr. R.S. Scorer	Mr. D.G.A. Rendel
	*Dr. J.M. Stagg	*Dr. G.D. Robinson
	*Dr. R.C. Sutcliffe	*Dr. J.M. Stagg
	*Mr. R.G. Veryard	*Dr. R.C. Sutcliffe

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I D E N T I A L

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The Committee decided in November, 1956 no longer to nominate certain of its number as members of Sub-Committees, except as chairmen, but that members of the Committee would continue to attend Sub-Committee meetings as appropriate.

5. General remarks. In relation to improving the forecasting of weather, intensive study has continued of methods of numerical forecasting based on dynamical principles in preparation for the additional facilities which will become available when an electronic computer (Ferranti Mark II) is installed in the Napier Shaw Laboratory at Dunstable during 1957. Investigations of the character and persistence of anomalies of surface air temperature suggest a line of approach which may be of value in forecasting some features for a few weeks ahead.

The possibility of augmenting rainfall as and when required is a matter of public concern in relation to water supplies, and has again received the close attention of the Committee. No convincing evidence has yet been found to encourage the belief that results of economic significance are within sight but research is being continued. The field trials at Salisbury Plain, in which finely-divided particles of silver iodide are released from generators at ground level, are based on the hypothesis that the particles will be dispersed to reach the sub-freezing levels in cloud and may give rise to increased rainfall detectable by analysis of the distribution of rainfall measured in the area downwind. The number of occasions suitable for trials has been insufficient so far for any conclusions to be drawn. Moreover, laboratory experiments at Porton suggest that the yield of silver iodide particles from the generators may be much lower than was previously supposed, while field experiments on the diffusion of airborne particles released from ground level suggest that in many conditions silver iodide particles do not reach the parts of the cloud where they may promote rain formation. The seeding of orographic cloud in hilly regions and the seeding of cumuliform cloud from aircraft have been considered, with the conclusion that large scale experiments should await results of research now in progress.

The range of slant visibility downwards from a height of a few hundred feet above the ground is an important factor to the safety of aircraft, especially jet aircraft, when landing in poor conditions of visibility. The problem is by no means new and investigational facilities (e.g., the use of large tethered balloons) are subject to restrictions, but a method of measurement suitable for research purposes has been devised. At a later stage the application to operations will be considered.

The Committee has taken note of a preliminary survey of a number of new research problems to which it would be very desirable to devote effort when resources permit; problems concerning, e.g., atmospheric chemistry, radio-activity and the high atmosphere. It was recommended that the chemical sampling of air and rainwater from a few stations in the British Isles should be arranged.

The Committee is pleased to have received evidence on the progress within the Meteorological Office of a variety of climatological investigations, several of which are of immediate application to agriculture and other parts of the national economy.

Reference is made again to the need of the Meteorological Research Flight for an aircraft capable of reaching 60,000 feet in order that investigation of wind structure, turbulence and contrails - items important to the Royal Air Force - may be continued to heights substantially greater than can be obtained by the present Canberra aircraft.

Experimental data which have been obtained by the Meteorological Office staff at Porton on eddy structure and the diffusion of airborne particles

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(lycopodium spores and cadmium zinc sulphide particles) over distances of a few hundred yards and also to distances of about 50 miles show interesting features in relation to the nature of atmospheric diffusion. The results from extension of the experiments are likely to be of significance to atmospheric problems other than that of the seeding of clouds from the ground.

The Committee is pleased to learn that an Assistant Director of the Meteorological Office is making a survey of the research requirements of tropical regions in collaboration with Colonial meteorological services, as arranged by the Colonial Office.

6. Collaboration with other bodies. Members of the Committee and Sub-Committees have continued association with the Gassiot Committee of the Royal Society and with other British and international organizations for meteorology and allied subjects. Members of the Committee and of the Meteorological Office have been closely concerned with arrangements for the International Geophysical Year, 1957-58.

The Committee has taken note of the proposed special additions to the Meteorological Office observational programme for the International Geophysical Year.

The Gust Research Committee (Aeronautical Research Council), which includes representatives of the Meteorological Research Committee and of which the present Chairman is Professor Sheppard, has again directed attention to the importance of obtaining more information on the structure of atmospheric gusts over a wide range of frequencies and at all heights at which aircraft operate.

As formerly, assistance has been received from research establishments of the Ministry of Supply in regard to the development of instruments involving electronic techniques.

Certain investigations are being conducted extra-murally with financial support from the Air Ministry, viz., at the University College of Wales, Aberystwyth: the development of an ionization method for measuring air density; at Bedford College, London: the preparation of a standard calendar of London daily meteorological observations, initially for the period 1723 - 1800; at the Imperial College, London: laboratory experiments on the air flow over hills.

Fundamental researches relevant to the properties of the atmosphere at high levels have continued at several universities in the United Kingdom, under the general oversight of the Gassiot Committee of the Royal Society and assisted by a grant-in-aid from the Air Ministry. The scope of the investigations, including now the exploration by rockets of the high atmosphere, is shown in the list given as Appendix 2 to the Programme of Investigations (M.R.P. 1034A). The Meteorological Office co-operates in the survey of atmospheric ozone by contributing daily measurements from three stations in the United Kingdom and has been concerned to arrange that similar measurements shall be made during the International Geophysical Year at Habbaniya, Argentine Is. in the Falkland Islands Dependencies, and Halley Bay on the Antarctic continent.

7. Meteorological Research Flight. The Flight, located at the R.A.E., Farnborough, is provided with one Hastings, one Canberra and one Varsity aircraft instrumented for investigations in cloud physics and atmospheric structure up to the lower stratosphere. During the summer, 1956, studies of the humidity of the lower stratosphere, hitherto almost entirely confined to the vicinity of the United Kingdom, were extended in a series of flights by the Canberra between about 20°N. and 68°N. Little variation in frost-point temperature was found. Assistance was given in the instrumentation of a Bristol Britannia aircraft to be used in investigating cloud conditions associated with engine failures, particularly in large cumulonimbus clouds over Africa. The microphysical data obtained on the Britannia explorations and similar data obtained during flights by the Hastings aircraft in the

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United Kingdom are being analysed. To provide information required in the study of radio-wave propagation (which is affected by the temperature and humidity structure of the atmosphere) it is proposed that the Flight shall obtain measurements of atmospheric refractive-index (using a microwave refractometer) and of the detail of temperature fluctuations.

8. General state of investigations. About 60 scientific papers and memoranda were considered by the Committee and Sub-Committees during the year. Comment is made below on several items of the Research Programme.

(a) Development of meteorological instruments

Progress was made in the perfecting of instruments for use on high-speed aircraft to measure and record air temperature and humidity, though some difficulties have still to be overcome.

Refinements have been made to the standard radio-sonde and radar equipment and technique used in measuring upper air temperature, humidity and wind by means of sounding balloons. There is particular need, however, to extend these soundings to greater heights (100,000 feet) but the radar sonde equipment, developed on Ministry of Supply contract, has not met all the Meteorological Office requirements and other techniques may prove more suitable.

The modulated-beam searchlight which has been developed to provide a continuous record of the height of the base of cloud at airfields has operated satisfactorily since it was brought into use at London Airport late in 1956, but it is hoped that the type of recording can be further improved.

A much improved instrument for registering the intensity of daylight illumination has been devised and is to be used at selected stations.

Measurement of the distance of visibility at night is attended by various difficulties and uncertainties. Trials of a 'matching' method, using a distant and a near light, have been instituted.

(b) Forecasting

The preparations made, as mentioned in paragraph 5, for extended use of numerical computation in weather prediction have included the study of the effects of the atmospheric structure assumed in the schematic models used in the numerical process, and of the computational errors (in the technical sense) which arise in the method of integrating by finite differences - errors which require more investigation. Further trials have shown that an objective analysis of upper air observations, using numerical methods, is likely to be satisfactory for numerical forecasting, with a considerable saving in time.

It is proposed to place more emphasis on a number of ad hoc problems of importance in day-to-day forecasting. These problems have been implicit in items of the Research Programme but are now more clearly specified.

A pioneer investigation of the variations of air and sea surface temperature (as observed at ocean weather stations) in relation to the general meteorological situation led on to the wider and important subject of the energy exchange between the sea and the atmosphere - a subject calling for further study.

Basic preparatory work related to problems of the general circulation of the atmosphere has been progressing.

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(c) Problems of direct interest to aviation

Reference is made in paragraph 5 to the renewed effort being made to investigate the slant visibility in the first few hundreds of feet above ground on misty or foggy occasions.

The effects of hills or mountains on airflow received further attention. Evidence of the character of the vertical motion in standing waves was obtained from radio-sonde observations at stations downwind of hills. A theoretical study of the airflow over a two-dimensional ridge has yielded additional insight into the influence of the structure of the atmosphere on the development of lee waves within a few thousand feet from the ground and also in stratospheric levels. The proposals, mentioned in the report for 1955/56, for using a specified incompressible fluid model to investigate this problem have been found impracticable at present. A relevant investigation is in progress at the Imperial College.

A detailed analysis of some 800 reports of aircraft icing, while indicating the variable nature of the phenomenon, resulted in some clarification of ideas on the type and severity of icing associated with different temperatures at flight level and with the prevailing meteorological situation. The reports examined confirm that icing is infrequent at temperatures less than -35°C.

On the basis of observations made by the Meteorological Research Flight on aircraft condensation trails it has been possible to formulate improved guidance for forecasting the length and persistence of condensation trails produced by jet aircraft. Consideration of the results of mixing of the exhaust gases with the surrounding air suggests the possibility of greater precision in the forecasting of condensation trails, if requisite performance and observational data were readily available.

A statistical method was developed for the rapid computation of equivalent head-winds on variable flight tracks and should be of value to the planning procedure of civil aviation operators.

(d) Exploration of the upper troposphere and lower stratosphere

As stated in paragraph 7 the atmospheric humidity at the greatest heights attainable by the Canberra aircraft of the Meteorological Research Flight was investigated in a series of flights between North Africa and well northwards of the British Isles. No further measurements were possible of the vertical distribution of atmospheric ozone, a subject of special interest to the Committee, as reliable equipment was not available. A promising ozone measuring technique, for use on radio-sonde balloons and aircraft, is under development by Dr. Brewer at the Clarendon Laboratory, Oxford.

Apparatus is being assembled for a modulated-beam searchlight to be used for measuring the air density to heights, about 60 km., well above those reached by sounding balloons.

(e) Radar in meteorological research

A recent study at the East Hill meteorological radar station has shown that the speed of travel of rain belts associated with cold fronts and cold occlusions is closely associated with the component of wind at 10,000 feet transverse to the front: a result of value in forecasting for short periods. A joint study by the Imperial College and East Hill of developing cumulus cloud, based on radar and visual

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observations and on associated aircraft measurements, provided information on radar echoes in convective weather but not caused by precipitation and also on the cloud processes resulting in shower formation. Further work on these lines is proposed.

(f) Agricultural meteorology

A series of experiments by the Meteorological Office unit at the School of Agriculture, Cambridge, depending on measurements of the vertical distribution of humidity, temperature and wind speed in a few feet above crops, indicated considerable differences between the daily water losses from different crops, e.g., grass pasture, peas and brussels sprouts.

Other investigations in progress include a survey of the liability to frost of several localities and field experiments on the effect of shelter barriers on the micro-climate of adjacent areas.

9. Research programme for 1957-58. The revised programme for 1957-58 is attached as an appendix. Items on which it is proposed to devote main effort include the following:-

(a) Development of thermometer elements and indicators for use at all aircraft speeds and all heights together with apparatus for automatic recording.

(b) Further improvements in and development of radio and radar techniques for the measurement of wind, temperature and humidity to heights of 60,000 ft. and above.

(c) Refinement of the modulated beam method for measuring cloud height in daylight.

(d) Development of airborne particle and nucleus samplers.

(e) The value of radar in weather forecasting.

(f) Orographic influences on airflow.

(g) Examination of the large-scale circulation patterns with a view to establishing techniques for long period forecasting.

(h) Studies of the deepening of depressions, their places of origin and changes of movement.

(i) Statistical study of low-level weather systems following the appearance of specified upper-air patterns; and the converse.

(j) Application of computing machinery to forecasting problems.

(k) Preparation of charts showing the variation of meteorological elements at various heights throughout the world.

(l) Experimental studies in atmospheric diffusion of matter and distribution of condensation and freezing nuclei with particular reference to the augmentation of rainfall.

(m) Physical structure of rain-producing clouds.

(n) The variation of wind in and around jet streams.

(o) Slant visibility in the first few hundreds of feet above the ground.